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BY: [illegible]

Date: October 25, 1998
To: Mr. Bruce Halstead, U.S. Fish and Wildlife Service
From: George Pess
Re: Comments on Volume IV - Pacific Lumber Company Habitat Conservation Plans, Sustained Yield Plan/Habitat Conservation Plan, Public Review Draft July 1998.
Permits: PRT-828950 and 1157

Below are detailed comments on Volume IV of the Pacific Lumber Company Habitat Conservation Plans, Sustained Yield Plan/Habitat Conservation Plan. Comments include references to other Volumes of the plan, such as Volume V, as well as the DEIS/EIR.

Page 7 – Section 1.1.3 – Rock and Gravel Mining, Rock Quarrying

GP-1

Rock and gravel mining can have significant adverse effects to fish and wildlife, which is why such activities are regulated under the California Environmental Quality Act (CEQA) and California Surface Mining & Reclamation Act. According to paragraph six of section 1.1.3 PALCO states the following:

> Quarries will be analyzed further during the watershed analysis process. This will provide the company with an opportunity to identify any necessary future mitigation at that time. All existing pits and quarries will be mapped through the watershed analysis process. New pits and quarries will be mapped when constructed.

PALCO goes on to identify in section 1.2.9 (watershed analysis) that they will utilize a modified version of the Washington (State) Forest Practice Board Manual entitled "Standard Methodology for Conducting Watershed Analysis - version 4.0," or the most current version.

However, there is no methodology within the Washington State manual that analyzes the effects of rock and gravel mining on fish habitat. This is known from having co-authored several of the Washington State watershed analysis modules, including the stream channel and fish habitat module, as well as participating in over four watershed analyses in Washington State. PALCO does not identify a specific methodology on how it will evaluate the potential adverse effects of rock and gravel mining on fish and wildlife, aside from stating that all new pits and quarries will be mapped when constructed. In my opinion, mapping quarries and pits, after they are constructed, does not constitute an scientific evaluation process that identifies potential adverse effects of mining to fish and wildlife.

Page 28 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.1.2 Storm Proofing

Forest roads can be a significant source of sediment to stream channels (Collins and Pess, 1997a). According to studies recently completed on PALCO land, forest roads can generate between 8% and 17% of the total sediment production within a watershed (Pacific Watershed Associates, 1998a; Pacific Watershed Associates, 1998b). Between 67% and 69% of the sediment delivery from roads is associated with landslides (mass wasting) (Pacific Watershed Associates, 1998a; Pacific Watershed Associates, 1998b). Large storms are a major trigger mechanism for such sediment inputs in PALCO watersheds (Pacific Watershed Associates, 1998a; Pacific Watershed Associates, 1998b). Consequently, storm-proofing roads is a critical step in reducing sediment input to streams.

PALCO identifies a road storm-proofing audit procedure on page 28, numbers 1 through 5. The procedure is similar to the detailed analysis developed and implemented by Pacific Watershed Associates (1998a, 1998b) for the North Fork Elk and Bear Creek watersheds. Details regarding the procedure are identified in Volume II, Part O (Assessment and Implementation Techniques for Road-related Sediment Inventories).

The methodology, developed by Pacific Watershed Associates, is a detailed analysis which requires a basic understanding of geology and geomorphic processes, as well as, an intimate understanding of how to quantify sediment production. PALCO identifies that "trained observers" will implement the audit, including the identification of potential erosion hazard areas, quantification of sediment deliver to stream channel, and remedial action that can help reduce sedimentation.

In my opinion, a detailed analysis such as the one described in this section, requires formal education in geology, with an emphasis in geomorphology, or forest hydrology and forest road engineering. Furthermore, years of experience on forest lands is also needed in order to help identify and quantify potential erosion hazards. The quality of the individual doing such analysis will have, in my opinion, a major effect on whether the audits are accurate, precise, repeatable, and thorough. PALCO does not give sufficient information to identify if such a person will be the trained observer. GP-2

PALCO also does not state if a detailed analysis, such as the ones completed for North Fork Elk and Bear Creek watersheds, will be implemented on each watershed. PALCO states that "at least 500 miles of existing roads will be improved to meeting the storm-proofing standards identified in the PWA guidelines (Volume II, Part N)." It is not clear if the 500 miles of road includes all watersheds in which PALCO owns land.

Page 28 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.1.3 Road Construction, Maintenance, Improvements, and Abandonment, Statement number 1

Forest roads can be a significant source of sediment to stream channels, either through surface erosion or by increasing landslide rates within a watershed (Collins and Pess, 1997a; Pacific Watershed Associates 1998a&b). Therefore, road construction, maintenance, improvement, and abandonment is an integral part of reducing sediment production to stream channel. Decreases in sediment production reduce the direct and cumulative effects of forestry on fish habitat and production.

The PALCO HCP recognizes the importance of a road management plan, and attempts to implement road management in the following manner:

> 1. For purposes of this (PALCO HCP) Plan, a road will be considered upgraded when it is well drained and shows no sign of imminent failure (e.g., as evidenced by slumping scarps, or cracks in the road fill) which deliver sediment to a watercourse.

This statement and prescribed management response does not utilize all the criteria and information gathered during the assessment of road and associated sediment sources, road storm-proofing, and watershed analysis, which PALCO identifies in Volume II, Part O (Assessment and implementation techniques for road-related sediment inventories), and sections 1.2.1.1 and 1.2.1.2 of this Volume. GP-3

According to the road erosion inventory methodology, future (expected) erosion and sediment delivery information will be gathered (Volume II, Part O, Pages 4 and 5; Pacific Watershed Associates, 1998a&b, Pages 7 and 9), including information of "potentially" unstable areas that do not show signs of "imminent" (e.g., visual) failure. However, poorly built or maintained roads that have not begun to show signs of visible failure (e.g., slumps, scarps, and cracks), but do have a high potential to fail due to unstable fill, or other problems, will not be upgraded.

PALCO does not describe why such areas where left out of the upgrade plan. A road maintenance and upgrade plan that does not include all potential high risk failure areas, regardless of whether or not they show current signs of failure, which can impact a watercourse, is likely, in my opinion, to lead to significant cumulative adverse impacts to fish habitat and production.

Page 29 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.1.3 Road Construction, Maintenance, Improvements, and Abandonment

Fish passage through structures such as culverts is critical to the potential recovery of salmonids. In Washington State, over 3,000 thousand miles of historic salmon habitat is currently blocked to fish passage (Conroy, 1997). Independent field surveys throughout Washington State have shown that large percentages of culverts either block fish passage, or impede passage (Pess and others, 1997). Culverts can also degrade fish habitat in other ways, including reducing nutrient distribution, which lead to a wide range of effects on the aquatic ecosystem (Cederholm and Peterson, 1985; Bilby and others, 1996). Coho salmon can be particularly effected by culverts in fish-bearing streams because of their tendency to move to the upper portions of watershed, and eventually into smaller streams (Scarlett and Cederholm, 1984).

The PALCO HCP identifies that fish passage will be accommodated for all new roads which pass over fish-bearing streams and "restorable" fish-bearing streams (Volume IV, section 1.2.1.3, page 29, first paragraph). PALCO, however, does not define what a "restorable" fish-bearing stream is, nor do they give any reference to information that is needed to define a restorable stream. According to my knowledge of the scientific literature no one has ever defined when a stream is or is not restorable.

GP-4

More importantly, PALCO does not address the need to evaluate if existing culverts are fish passage impediments. Work in other Pacific states, such as Washington, have identified and implemented large-scale programs which inventory and identify culverts blocking salmon passage (Conroy, 1997). For example, the Snohomish River, a 1200mi2, watershed in Western Washington that includes a significant portion of its land in managed timberlands, has had field crews from five agencies (local county governments, non-profits, tribes, state agencies, and federal agencies) implementing culvert inventories for over four years. This effort has resulted in approximately 25% of the entire basin being inventoried, with 75% remaining. In some cases, 50 to 75% of the existing culverts in a watershed that has forestry as its primary land-use are fish passage blockages (Conroy, 1997). The Stillaguamish River, a 700mi2 watershed in Western Washington, has had a culvert inventory recently completed for over 50% of the basin. Blocking culverts have reduced potential coho smolt production in small stream habitat by 38% to 40% from historic conditions (Pess and others, 1997). Approximately 60 miles of small stream habitat is blocked for at least one coho freshwater life stage (Pess and others, 1997). The DEIS/EIR for the Headwaters Forest Acquisition, and the PALCO Habitat Conservation Plan and Sustained Yield Plan also identifies that critical freshwater habitat for juvenile coho is particularly susceptible to human disturbance such as fish passage barriers that prevent upstream access or modify downstream conditions (USFWS, October 1998, page 3.8-23). Based on this, and other efforts throughout the entire region where salmon occur, it is clear that existing blocking culverts are a problem.

PALCO does not address the issue of existing blocking culverts, even though it, in all likelihood, is a problem, particularly to coho. In addition, state and local rules that govern the design of water crossing structures for roads normally include a specific provision for fish passage (e.g., Washington State Administrative Code 222-24-050). It is my opinion that existing blocking culverts do have a significant adverse effect of coho use and production, and do result in the loss of fish over time. Leaving existing blocking culverts in streams will reduce the recovery of wild salmon stocks, such as coho, because of a reduction in the amount of total available habitat. GP-4 con.

Page 30 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.2.1 Channel Migration Zone GP-5

The channel migration zone (CMZ) is a critical concept to incorporate into riparian and land management because rivers with flood plains can migrate laterally by eroding their banks, or shift channels abruptly during floods (Dunne and Leopold, 1978). In order to plan for the future recruitment of large woody debris (LWD) to stream channels, it is necessary to maintain a riparian forest on the entire flood plain, as well as the adjacent slopes. PALCO states the definition of the CMZ as the following:

> All segment of Class I and Class II streams that have a Rosgen type C, D, or E channel morphology will be examined to identify the current boundaries of the active channel during the 50 years covered by the Incidental Take Permit (ITP) as evidenced by the past channel migration and other field indicators.

The CMZ definition in Volume IV is not consistent with other definitions that have been developed by the National Marine Fisheries Service (NMFS), and other HCP plans such the Washington State Department of Natural Resources (WDNR). NMFS defined the CMZ, in the draft proposal on Oregon Forest Practice Rules (February 17, 1998) as:

> The area a stream is expected to occupy in the time period it takes to grow a tree of sufficient size to geomorphically function in the channel. Spatially, this area generally corresponds to the modern flood plain, but can also include river terraces subject to significant bank erosion. An acceptable method for delineating the CMZ at a particular site involves delineating either the flood-prone area or the approximate 100-year flood plain, whichever is greater. For larger streams, the 100-year flood plain may already be available on U.S. Army Corps of Engineers or county flood hazard maps. A field method for delineating the flood-prone area is approximated by "*Applied Fluvial Morphology*" (Rosgen, 1996). The flood-prone area is approximated by the area that would be inundated by stream flows of two times the bankfull depth. The objective of identifying the CMZ is to ensure that the stream has a protective buffer in the future, even if the stream were to move away from its present location.

The NMFS definition of CMZ takes into account important aspects that will lead to more protection for fish habitat. First, the NMFS definition considers the concept of functioning wood size, which means that a piece of wood needs to a minimum size in order to be stable and create specific habitat features such as pools (Bilby and Ward, 1989; Montgomery and others, 1995), or perform certain geomorphic functions such as bank protection, sediment storage, or wood debris storage (Montgomery and Buffington, 1997). Channels that are larger in width, consequently, need larger pieces of wood. Second, by including the 100-year flood plain, a greater spatial extent is included, which means that there is a higher likelihood for a channel to have riparian protection, assuming the CMZ includes a no-harvest buffer.

The NMFS definition gives more resource protection because it utilizes a greater spatial and temporal extent, which is scientifically more accurate because we cannot accurately predict future channel locations, especially in forested channels which have a tendency to move in significant, discrete steps (e.g., avulsions).

GP-5 CON.

The NMFS draft forest practice rules for Oregon, and other HCPs, provide a more scientifically credible and conservative definition of a CMZ. PALCOs definition has a greater probability of leading to significant adverse impacts than the NMFS definition. The dynamic nature of a CMZ and the flood plain, in my opinion, warrants a definition that encompasses a greater percentage of the total area than how it is defined in the PALCO HCP.

Page 31 through 34 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.2.2 Class I Stream Buffers

Adequate stream buffers which protect and enhance stream habitat for salmonids, such as coho, is critical to the potential success of any HCP. A recent National Research Council (NRC) publication titled, Upstream: Salmon and Society in the Pacific Northwest states the following:

> Perhaps no other structural component of the environment is as important to salmon habitat as is large woody debris, particularly in coastal watersheds...Loss of large woody debris from streams usually diminishes habitat quality and reduces carrying capacity for rearing salmon during all or part of the year (Hicks and others, 1991) (p. 194)

Large woody debris (LWD) that falls into stream channels from riparian areas creates and maintains freshwater habitat. Of more specific importance is the role of wood in creating pools and slower water habitat types for juvenile and adult coho (Scarlett and Cederholm, 1984; Beechie and others, 1994; USFWS, 1998; Montgomery and others, in press;). A local decrease in chinook and coho spawning abundance accompanied a loss of wood debris and wood-formed pools in several streams in Western Washington (Montgomery and others, in press). Spawning nest (or redds) density went from 30 to 240 redds/km down to 0 to 20 redds/km (Montgomery and others, in press). The loss of LWD due to removal of wood from stream channels and the lack of adequate riparian protection is likely to lead to the continued decline of coho salmon habitat.

The PALCO stream buffer plan has several key aspects which reduce the potential success at protecting and enhancing freshwater coho salmon habitat. This list includes the following from pages 31 through 34 of Volume IV, Section 1.2.2.2:

- All fish bearing (or restorable) Class I streams as defined in the CFPRs will have a Riparian Management Zone....
- The RMZ will measure 170ft (slope distance)...
- The Class I streams is divided into three management bands, the Restricted Harvest Band (RHB), the Limited Entry Band (LEB), and the Outer Band (OB). The bands are measured 0ft to 30ft, 30ft to 100ft, and 100ft to 170ft...
- There will be a maximum of 1 entry every 20 years.
- A minimum 300sq-ft post harvest conifer basal area per acre will be retained with the LEB.
- Tree sizes and quantity distribution will be retained as per Table 4...
- A minimum of 240sq-ft post harvest conifer basal area per acre will be retained.
- Tree sizes and quantity distribution will be retained as per Table 4.

PALCO does not define what a "restorable" fish-bearing stream is, nor do they give any reference to information that is needed to define a restorable stream. According to my knowledge of the scientific literature no one has ever defined when a stream is or is not restorable. This will limit where the Class I stream buffer prescription is applied, and can reduce the overall spatial extent of riparian protection. Reducing the overall extent of riparian protection will reduce wood loading and pool habitat in areas that either have coho use, or historically had coho use. GP-6

Enough information is not given in Volume IV, section 1.2.2.2 to justify the riparian buffer width distance of 170ft. According to DEIS/EIR (Chapter 3.7, page 36): GP-7

> A site potential tree height is approximately 170 feet at 100 years for PALCOs ownership. In some cases, however, the redwood zone's on PALCO's land can contain site-potential trees in excess of 200 feet at 100 years; consequently, the riparian zone of influence extend farther from the stream channel in these systems.

A tree height site potential is the estimated height of a specific tree species (e.g., Redwood, Douglas-fir) at a given age class. FEMAT (1993) asserted that the majority of riparian functions, including LWD recruitment, occurred within one tree height site potential from the stream or flood plain. The DEIS/EIR (3.7-page20, Figure 3.7-2b) points out that others, such as Van Sickle and Gregory (1990), have modeled this and shown that large wood from outside one tree height site potential seldom reaches the stream. Volume V (Maps and Illustrations), map 6 shows that PALCO has tree height site potential data for all its lands. If data exists for tree height site potential, and it is part of the HCP/SYS, then it should be used to help determine the buffer width for each riparian zone. Stream channels that have riparian areas with a site potential tree height greater than 170ft at 100 years will start with less than 100% potential protection. PALCO does not give enough information to; 1) justify why 170ft was chosen, and 2) determine the potential adverse impacts of deciding not to use actual site potential with each stream buffer. Starting at less than 100% potential protection decreases the recovery rates of degraded stream channels, which lack wood and pools. Decreasing habitat recovery rates will result in less potential coho production over the life of the HCP, and lead to adverse effects on coho production.

PALCO does not give enough information to determine if the three bands - restricted harvest band (RHB), limited entry band (LEB), and outer band (OB), within the RMZ are scientifically justifiable. The only assumption that can be made is that each allows for progressively more management activity because the potential to recruit LWD decreases going away from the stream channel. However, it is not clear why 30ft was chosen as the RHB and 100ft for the LEB. The 170ft OB is based upon an average site potential for PALCO lands. Even though the stream buffers start at the edge of the CMZ, it is not clear if the stream buffers will protect areas with actively eroding terraces or stream banks. If not, then large portions of the stream buffer will be lost to the stream channel in a short time period. For example, recent studies on PALCO lands (PWA 1998a&b) found that bank erosion rates average 2.5ft per year and range between 1ft to 30ft per year. The majority of erosion occurs during high flow events. A 30ft RHB along a channel with a actively eroding bank that is not part of the CMZ, but is either a terrace or steep bank, can be lost within one year. On average, the 30 RHB could be lost within a 12 year time period. GP-7 CON.

AB 1986 states that the final HCP shall establish a no-cut buffer of 100 feet on each side of each Class I watercourse, until watershed analysis is reviewed by the USFWS or NMFS, or site-specific prescriptions are established by USFWS or NMFS. A 100ft no-cut buffer along a channel with a actively eroding bank that is not part of the CMZ, but is either a terrace or steep bank, can be lost in less than four years. On average, the 100 RHB could be lost within a 40 year time period, less than the life of the HCP. More information is needed to determine if bands or zones will give enough protection not to have significant adverse effects on freshwater coho habitat. There is also a lack of information on justifying how one entry in the stream buffer for harvest every 20 years would not reduce wood loading levels to a point of adversely affecting coho production.

PALCO identifies minimum post harvest basal area retention requirements (Table 4, page 34), but does not give enough information to analyze the projected impact of the stream buffer on wood loading, and the scientific justification for each post basal area requirement. The only information given about the science behind the retention numbers of 300 and 240 sq. ft per acre is given in Chapter 3.7, page 57 of the DEIS/EIR:

> There is no data in the literature that conclusively demonstrates that this 300-square-foot basal area late seral selection; high residual basal area prescription would guarantee an 80 percent or greater canopy overstory. However, experience indicates that this 300-square-foot basal area prescription with a dbh size distribution described in Appendix J would result in at least an 80 percent canopy cover, especially when combined with a 30-foot, no harvest zone next to the stream (Personal communication, Marc Jameson, CDF, 1998).

The same is also said for 240 sq. ft target. Targets are thus set without any scientific justification, with the exception of one individual's opinion on whether canopy cover estimates are met. In my opinion, experimental prescriptions, such as this one, should be treated as an experiment, and include a hypothesis, study design, and an overall smaller scale approach before it is implemented on an HCP scale. My opinion comes from reviewing numerous experimental riparian prescriptions written without scientific justification in Washington State (Collins and Pess, 1997).

The retention standards also do not attempt to define how many trees per acre of a given size are maintained. The only limit to how many larger trees are retained is 10 trees per acre, per side that are greater than 40" DBH, or the 10 largest trees, per side. Leaving 20 trees greater than 40" DBH, or 20 of the largest trees will not be enough to provide stable LWD in larger streams and rivers. These large trees have been shown to be necessary to catalyze log jam formation and associated habitat elements in large stream channels (Abbe and Montgomery, 1996; Montgomery and others, 1996). The minimal number of large trees left within the RMZ will not be enough to create and maintain key habitat structures such as log jams, which create large and high quality pool habitat. The PALCO DEIS/EIR also recognizes the importance of large trees in larger streams: GP-8

> Redwood and Douglas-fir late seral stage stands would not likely have enough large trees to provide stable LWD in larger streams and rivers. These water bodies may require recruitable trees as great as 40 inches dbh (at a minimum) to be considered key pieces for long-term contribution to aquatic habitat (see Section 3.4); otherwise they are at risk of floating away in large flood events.

A basal area requirement that does not include a trees per acre requirement, as well as a size class distribution requirement, allows for the removal of large (e.g., > 40" DBH) trees. Again, these trees are essential to the development of critical coho habitat through the formation of log jams because they are stable obstructions. Such trees can last hundreds of years in streams of the Pacific Northwest (Personal communication with Tim Abbe, Ph.D. candidate, University of Washington, October 29, 1998). Removing large trees along large streams, that are already depleted of LWD, will have significant long-term adverse effects on coho habitat.

Page 35 through 37 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.2.3 Class II Stream Buffers GP-9

The PALCO stream buffer plan for Class II streams has several key aspects which reduce the potential success at protecting and enhancing freshwater coho salmon habitat. This list includes the following from pages 35 through 37 of Volume IV, Section 1.2.2.3:

- The RMZ will measure 100ft (slope distance)...
- The Class II streams is divided into two management bands, the Restricted Harvest Band (RHB) and the Selective Entry Band (SEB). The bands are measured 0ft to 10ft and 10ft to 100ft...
- There will be a maximum of 1 entry every 20 years.
- A minimum of 240sq ft post harvest conifer basal area per acre will be retained.
- Tree sizes and quantity distribution will be retained as per Table 4.

Enough information is not given in Volume IV, section 1.2.2.2 to justify the riparian buffer width distance of 100ft. According to DEIS/EIR (Chapter 3.7, page 36):

> A site potential tree height is approximately 170 feet at 100 years for PALCOs ownership. In some cases, however, the redwood zone's on PALCO's land can contain site-potential trees in excess of 200 feet at 100 years; consequently, the riparian zone of influence extend farther from the stream channel in these systems.

In addition, Volume V (Maps and Illustrations), map 6 shows that PALCO has tree height site potential data for all its lands. If data exists for tree height site potential, and it is part of the HCP/SYS, then it should be used to help determine the buffer width for each riparian zone. Stream channels that have riparian areas with a site potential tree height greater than 100ft at 100 years will start with less than 100% potential protection. PALCO does not give enough information to; 1) justify why 100ft was chosen, and 2) determine the potential adverse impacts of deciding not to use actual site potential with each stream buffer. Starting at less than 100% potential protection decreases the LWD input rates to degraded stream channels. Decreasing LWD input rates will result in less potential coho production over the life of the HCP, and lead to adverse effects on coho production.

GP-9 con'.

PALCO does not give enough information to determine if the two bands - restricted harvest band (RHB), selective entry band (SEB), within the RMZ are scientifically justifiable. The only assumption which can be made is that each allows for progressively more management activity because the potential to recruit LWD decreases going away from the stream channel. However, it is not clear why 10ft was chosen as the RHB and 100ft for the SEB. Even though the stream buffers start at the edge of the CMZ, it is not clear if the stream buffers will protect areas with actively eroding terraces or stream banks. If not, then large portions of the stream buffer will be lost to the stream channel in a short time period. For example, recent studies on PALCO lands (PWA 1998a&b) found that bank erosion rates average 2.5ft per year and range between 1ft to 30ft per year. The majority of erosion occurs during high flow events. A 10ft RHB along a channel with a actively eroding bank that is not part of the CMZ, but is either a terrace or steep bank, can be lost within one year. On average, the 10 RHB could be lost within 4 years.

AB 1986 states that the final HCP shall establish a no-cut buffer of 30 feet on each side of each Class II watercourse, until watershed analysis is reviewed by the USFWS or NMFS, or site-specific prescriptions are established by USFWS or NMFS. A 30ft no-cut buffer along a channel with a actively eroding bank that is not part of the CMZ, but is either a terrace or steep bank, can be lost in one year. On average, the 30 RHB could be lost within a 12 year time period, less than the life of the HCP. More information is needed to determine if bands or zones will give enough protection not to have significant adverse effects on freshwater coho habitat. There is also a lack of information on justifying how one entry in the stream buffer for harvest every 20 years would not reduce wood loading levels to a point of adversely affecting coho production.

PALCO identifies minimum post harvest basal area retention requirements (Table 4, page 34), but does not give enough information to analyze the projected impact of the stream buffer on wood loading, and the scientific justification for each post basal area requirement. In my opinion, experimental prescriptions, such as this one, should be treated as an experiment, and include a hypothesis, study design, and an overall smaller scale approach before it is implemented on an HCP scale. My opinion comes from reviewing numerous experimental riparian prescriptions written without scientific justification in Washington State (Collins and Pess, 1997).

The retention standards also do not attempt to define how many trees per acre of a given size are maintained. A basal area requirement that does not include a trees per acre requirement, as well as a size class distribution requirement, allows for the removal of larger trees. These trees are essential to the development of sediment storage locations within Class II stream channels. GP-9 CON.

Wood stores sediment in steep channels by forming steps in the stream bed, resulting in sediment accumulation. This limits the amount of sediment which moves downstream, thereby reducing impacts to fish habitat and water quality. LWD also helps stabilize hillsides and dissipate stream energy by reducing the effective channel slope (Megahan, 1982; Keller and others, 1996; Haas, 1996). This reduces the amount of energy available for bank and bed erosion, thereby reducing stream channel incision.

In the Northern Redwood Creek basin, Keller and others (1996) found that up to 70% of increase in stream channel slope with first and second order stream reaches was controlled by the loss of LWD. Removing large trees along Class II streams, that are already depleted of LWD, is likely to have significant long-term adverse effects on downstream coho habitat by reducing the amount of upstream sediment storage locations, and subsequently increasing the amount of downstream sediment impacts.

Page 38 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.2.4 Class III Stream Buffers GP-10

The PALCO stream buffer plan does not leave any trees along Class III streams. Wood is important in Class III streams because it stores sediment by forming steps in the stream bed, resulting in sediment accumulation. This limits the amount of sediment which moves downstream, thereby reducing impacts to fish habitat and water quality. LWD also helps stabilize hillsides and dissipate stream energy by reducing the effective channel slope (Megahan, 1982; Keller and others, 1995; Haas, 1996). This reduces the amount of energy available for bank and bed erosion, thereby reducing stream channel incision.

In the Northern Redwood Creek basin, Keller and others (1995) found that up to 70% of the increase in stream channel slope with first and second order stream reaches was controlled by the loss of LWD. An increase in channel slope increases stream power and reduces the number and size of sediment storage sites. A decrease in LWD obstructions decrease the amount of sediment retained, and results in an increase in sediment production from a first and second order streams. Approximately 5 to 30 times the amount of sediment that is moved out of a watershed is stored within the stream channel behind LWD obstructions (Megahan, 1982). Removing all trees along Class III streams is likely to have significant long-term adverse effects on downstream coho habitat by reducing the amount of upstream sediment storage locations, and subsequently increasing the amount of downstream sediment impacts.

Page 46 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.9 Watershed Analysis

Watershed analysis is an integral part of the PALCO HCP/SYS. PALCO will conduct watershed analysis "...on all of its ownership (Volume IV, section 1.2.9, page 46)." Watershed analysis will allow PALCO to get away from a "one size fits all" approach to land management, and attempt to create management strategies that are:

> ... tailored to the environmental factors and current influences that shape each watershed (Volume IV, section 1.2.9, page 46).

PALCO's hypothesis is that "watershed analysis will result in site specific management prescriptions." PALCO will use the following watershed analysis methodology:

> a modified version of the Washington Forest Practices Board Manual: Standard Methodology for Conducting Watershed Analysis - Version 4.0 November 1997 (Washington Department of Natural Resources methodology) or the most current version at the time of analysis.

The Washington State watershed analysis methodology does not, in most cases, lead to watershed specific prescriptions (Collins and Pess, 1997a). This statement is based on my experience; 1) helping to develop the watershed analysis modules (stream channel and fish habitat), 2) participating in four Washington State watershed analyses, and 3) reviewing and analyzing prescriptions from the first 20 Washington State watershed analyses (Collins and Pess 1997a, 1997b). GP-11

Our review of prescriptions from the first 20 watershed analyses completed in Washington State found that the majority of prescriptions were similar in form and content to the state standard rules (Collins and Pess, 1997a). Prescriptions that did vary from standard rules incorporated additions that increased state authority, identified specific "hazard" areas such as slopes more prone to landslides or more sensitive to increases in erosion rates, and were more systematic and detailed. The majority of prescriptions, however, closely follow the standard rules because the scientific assessment methodology in the Washington State watershed analysis manual "closely follows" the standard rules (Collins and Pess, 1997a).

For example, the most common mass wasting prescription (65 out of 117 or 56%) requires a site evaluation by a specialist in a particular map unit that includes an unstable landform such as an inner gorge. The Washington State standard rule requires that an environmental checklist be completed under the Washington State Environmental Policy Act for proposed timber harvest in "slide prone areas" (Collins and Pess, 1997a). This, in most cases, includes a site evaluation by several specialists. Furthermore, the majority of these mass wasting prescriptions do not require a systematic method to identify the risk of landslide hazard. This means different specialists can use their "best professional judgment" without any more data, utilize various methods that may not be repeatable by others, or focus on determining existing stability rather than potential future stability (Collins and Pess, 1997a).

In addition, the majority of prescriptions developed for specific issues in watershed analysis, such as mass wasting, are somewhat generic because watershed analysis does not produce the site-specific data necessary for managers to prescribe site-specific remedies (Collins and Pess, 1997a). In some cases, site-specific data generated during the assessment process or the scientific literature is not used by land managers to develop prescriptions (Collins and Pess, 1997a). For example, approximately 25% (29 out of 117 reviewed) of mass wasting prescriptions allow partial harvest operations of dominant trees in areas identified as having a high likelihood of landslide failure, if "understory" or "unmerchantable" (e.g., small shrubs and trees) trees are maintained (Collins and Pess, 1997a). The belief is that understory will maintain root strength. However, there is little support in the scientific literature that "understory" and "unmerchantable" trees alone provide adequate rooting strength on unstable terrain (Collins and Pess, 1997a). GP-11 CON.

In my opinion, it is likely that PALCO watershed analysis will not result in many site specific management prescriptions. This is based on my experience in developing, implementing, and analyzing Washington State's watershed analysis process, which is the basis of PALCO's future efforts.

PALCO also states the following:

> After watershed analysis is completed specific prescriptions can be implemented that will maintain and/or enhance the aquatic environment based on the current conditions and the future needs identified in that area (Volume IV, section 1.2.9, page 46).

The goal PALCO defines in this statement is similar to Washington State's watershed analysis goal, which is to "prevent adverse effects of forest practices on aquatic resource of the state" (Collins and Pess, 1997b). The basis of this statement is that land management prescriptions will be based upon the assessment and scientific literature.

Our review of the first 20 Washington State watershed analysis prescriptions indicates that many prescriptions are not based on the assessment or most recent science (Collins and Pess, 1997a). This results in prescriptions that do not "maintain and/or enhance the aquatic environment" to the point of preventing cumulative adverse effects (Collins and Pess, 1997b).

We found that almost two out of every three prescriptions (260 out of 430, 60%) were based on hypotheses that lacked enough scientific justification to guarantee success in meeting the watershed analysis goal of protecting and restoring aquatic habitat without testing. In addition, 16% of prescriptions did not even attempt to scientifically justify prescriptions (Collins and Pess, 1997a). In my opinion, if PALCO's site-specific prescriptions follow the same trend as in Washington State, then it is likely that future land management will not result in the maintenance and enhancement of aquatic habitat.

Page 48 – Section 1.2 - Aquatic Habitat Conservation Measures to be Implemented Under the Plan, 1.2.9 Watershed Analysis GP-12

PALCO states the following with respect to what will be in their watershed analysis methodology:

> PL's watershed analysis will consist of eight parts or "modules": mass wasting, surface erosion, riparian function, stream channel, fish habitat, amphibian and reptile, synthesis and prescription setting.

PALCO does not identify any method to analyze the effects of forestry activities on streamflow regime, even though streamflow alteration during high and low flows can have significant adverse effects of coho production. Increases in the magnitude of peak runoff can increase the depth and frequency of bed scour, which results in a decrease in salmonid survival from the egg to fry life stage (Montgomery and others, in press). Forest roads can affect the timing, quantity, and quality of water delivered to stream channels by increasing stream channel density, hasten subsurface flows, and increase peak flows (Jones and Grant, 1996; Wemple, 1994). GP-12 con.

The DEIS/EIR state the following with regards to increased peak flows due to forest roads:

> No specific mitigation has been identified for increased peak flows due to roads under the alternatives. However, some incidental protection would be provided such measures as using outsloping on new roads wherever possible, and appropriate spacing of ditch relief culverts. These measures would decrease the risk of and/or volume of increase peak flows. Although the unmitigated risk of peak flows would be moderate to high, with the above mitigation it would be reduced to a moderate level (Page 3.4-36).

The lack of a method to identify the effect of road building on peak flows, and subsequent effects on stream channels, fish habitat, and fish production can, in my opinion, result in significant long-term cumulative adverse effects to coho habitat.

Page 96,98 and 99 – Section 2.0 - Implementation of the Plan, 2.1 - Habitat Condition Goals

GP-13

Table 7 ("Key goals for properly functioning condition identified by the Interagency Matrix," Volume IV, page 98) identifies key water quality, habitat elements, and riparian buffer parameters to be used as criteria to assess "properly functioning habitat" conditions. The federal agencies and Pacific Lumber agree to the following:

> ..if successful, the aquatic conservation strategy should lead to stream conditions that trend toward the key goals in the matrix. Thus, by agreement with the agreement with the agencies: 1) the matrix is used here to identify a desirable future condition that the aquatic strategy will strive to achieve, and 2) the matrix does not constitute enforcement standards that must be achieved during the life of the plan.

The HCP goes on to identify several variables that can be used to assess the "efficacy" of the aquatic conservation strategy, including large woody debris volume, pool frequency, and pool area. The habitat conditions goals identified for large woody debris and pool abundance in table 7 are not based upon, and in some cases, contradict the most recent scientific literature. Furthermore, the matrix does not identify and take into account critical habitat types that limit freshwater coho production.

<u>LWD volume</u>

The LWD volume targets in the matrix do not include a goal for functioning LWD. The scientific literature identifies that LWD size (e.g., length and diameter of a tree) is important because it determines whether wood "properly functions" in a stream (Bilby and Ward, 1989; Montgomery and others, 1995; WFPB, 1995; Beechie and Sibley, 1997; Kennard and others, 1998). For example, Bilby and Ward (1989), found that in order for LWD to be stable in smaller stream channels (less than 25 meters bankfull width) and function to create pools, store sediment and reduce bank erosion, average LWD size needs to increase with channel width. Others have also found this relationship to be true, especially when LWD functions to create and maintain pools (Montgomery and others, 1995; WFPB, 1995; Beechie and Sibley, 1997; Kennard and others, 1998). Abbe and others (1997) have defined a way to determine the functioning size of wood in larger streams (e.g., greater than 30 meters bankfull width), which is based on bankfull depth in relation to the size of wood. In both cases, there is a minimum functioning LWD size, and a given size that achieves specific functions such as pool formation.

The HCP wood volume goals by channel width can be met without having LWD that functions to create desired habitat characteristics, such as pools, because table 7 does not identify a minimum functioning size for each channel width. This goal also contradicts what was developed by NMFS in September of 1996. According to NMFS (1996) properly functioning LWD needs to have a minimum diameter of 24 inches. A wood volume target, without a companion minimum functioning LWD size target, is likely to result in significant cumulative adverse effects. GP-13 con.

Pool frequency

The goal of 6 channel widths per pool[1] is typical of low gradient (<3%) channels, and can be met with or without wood. Published data on pool frequency v. wood loading show that some forest channels that are severely depleted in LWD will still meet the proposed goal (Montgomery and others, 1995). Beechie and Sibley (1997) examined 28 second-growth streams in Western Washington and found that all but one stream had less than 6 channel widths per pool. The one stream that did not meet this level had a dam-break flood take out all functioning wood for the lower several miles. Pool frequency in streams with old growth riparian areas average 1 channel width per pool, but more importantly only range between 0.5 and 2 channel widths per pool (Montgomery and others, 1995). Washington State's watershed analysis manual identifies that channels less than 3% gradient and 15m in width are in "good" condition if pool spacing is less than 4 channel widths per pool. The goal of 6 channel widths per pool will also be met in steeper channels, regardless of wood loading (Montgomery and others, 1995).

A local decrease in chinook and coho spawning abundance accompanied a loss of pool frequency and wood debris in several streams in Western Washington (Montgomery and others, in press). Spawning nest (or redds) density in areas where pool spacing was less than 4 channel widths per pool ranged between 10 to 240 redds/km, averaging 106 redds/km (Montgomery and others, in press). In streams where pool spacing was greater than 4 channel widths per pool redd density ranged between 0 to 20 redds/km, and averaged 3 redds/km (Montgomery and others, in press). The HCP goal of 6 channel widths per pool establishes a standard that maintains stream channels in a degraded condition, and is likely to significantly reduce coho spawning utilization.

Percent pool area

The HCP's goal of greater than 20% and 25% pool surface area can also be met, regardless of wood loading. Beechie and Sibley (1997) found that only three of twenty - eight streams in second growth forest in Western Washington had a percent pool area less than 20%. Streams with gradients less than 4% in old growth forests of the Pacific Northwest can have an average percent pool area of 54% (Ralph and others, 1994). The Washington State watershed analysis manual identifies that channels which have a gradient less than 4% are considered to be in fair or poor conditions with pool areas of 40% or less (WFPB, 1995). The percent pool area goal identified in table 7 also contradicts what was stated as "high" in Volume II, page 12, which is pool percentages greater than 40%. Volume II identifies that a pool percentage area of greater than 25% is

[1] Channel widths per pool describes the distance between two pools by bankfull channel width. For example, if there is a pool every 100ft, and the bankfull channel width is 10ft, then there are 10 channel widths between pools or 10 channel widths per pool. Normalizing the distance allows for comparisons between large (e.g., greater than 100ft channel width) and small (e.g., 10ft channel width) stream channels.

considered to be the threshold between moderate and low. Once again, the goal establishes a standard that maintains stream channels in a degraded condition, and is likely to in significant adverse effects.

GP-13 con.

Failure to identify essential habitat

The lack of identification of essential habitat with respect to the various life stages and life history strategies for all salmonids, especially coho, is perhaps one of the largest flaws in the entire PALCO HCP. According to the "properly functioning habitat" conditions matrix in Volume IV, Part D, Section 6, off-channel habitat is part of the essential habitat elements that need to be part of any recovery effort. Off-channel habitat includes slower water habitat that is not part of a main stem of a river, but is still hydrologically connected either through surface or subsurface flow. Such areas are normally found in the flood plain and include old river meander bends (oxbows) or side-channels which convey water during high flows. These areas are essential rearing habitat for juvenile salmonids, such as steelhead and coho. Table 7 makes no mention of off-channel habitat. It has been documented in the Pacific Northwest that winter and summer rearing habitat is the current freshwater habitat factor limiting coho production (Beechie and others, 1994).

Studies estimate that more than 50% of this habitat type has been lost to diking, dredging, levees, channelization, ditching, and riparian conversion over the last 100 years (Beechie and others, 1994). Protection and restoration which does not take into account what limits fish production will not be successful, because the capacity of the system does not change. In short, if the limiting factor, or "bottleneck," is not addressed, then actions will not result in a change in the potential number of fish. Table 7 does not include any targets on essential habitat types that need to be maintained and restored for future coho production, even though Volume IV, Part D, Section 6 and the scientific literature documents the importance of such habitats. This, in my opinion, is likely to result in significant adverse effects to coho habitat and potential coho smolt production.

Pages 99 to 101 – Section 2.2 - Monitoring, 2.2.1 - Monitoring Program Objectives and 2.2.2 - Focus of the Aquatic Monitoring Program

GP-14

PALCO identifies several types of monitoring in its program including: 1) compliance monitoring, 2) trends monitoring, and 3) effectiveness monitoring. Compliance monitoring is defined as the implementation of prescriptions. Trend monitoring is defined as measuring the change in aquatic resources over time, in response to prescriptions. Effectiveness monitoring is the assessment of prescriptions on aquatic resources. For example, effectiveness monitoring can, in theory, answer the question of whether or not riparian prescriptions are maintaining or obtaining certain levels of LWD recruitment over a specific time period. PALCO summarizes the intent of the monitoring program as the following:

> ..the monitoring program is designed to provide data to determine whether conditions in PL's streams are trending toward the key properly functioning goals (Table 7, Figure 6). Where such trends are evident, it is likely that animal populations that depend upon these parameters will persist and/or recover (Volume IV, Section 2.2.2 Focus of the Aquatic Monitoring Program, page 101).

PALCO assumes that if the key properly functioning condition goals are met, then animal populations will recover over time. A trend towards, or attainment of, the key habitat goals in Table 7 determines the success of the PALCO HCP. GP-14 CON

Under the proposed HCP, effectiveness monitoring will ask the basic question:

- "Is there a trend towards the goals identified in the properly functioning habitat goals identified in Table 7?"

A more important question not asked as part of effectiveness monitoring is:

- "What is the appropriateness of the assumptions made which define the habitat goals, and in turn, define the success of the PALCO HCP?"

As previously stated, many of the habitat conditions goals, such as those for LWD and pool abundance, are not based upon, and in some cases, contradict the most recent scientific literature. The key habitat condition goal table also does not incorporate the maintenance and restoration of critical habitat elements, such as key habitat types (e.g., off-channel rearing habitat) for coho. Key habitat goals are hypotheses themselves, and need to be scientifically tested and validated. A management goal or objective, which drives the definition of a successful or unsuccessful plan, is appropriate only if it is also being tested as a hypothesis (Collins and Pess, 1997b). In my opinion, it is likely that the PALCO monitoring plan will be able to determine the trend in properly functioning variables such as LWD volume and pool abundance. However, the monitoring plan will, more than likely, not answer a more fundamental question as to the appropriateness of the identified goals, and how they relate to coho habitat and population levels. In my opinion, the goals identified in Table 7 will likely maintain stream conditions in a degraded state and result in significant adverse effects. More important, the proposed HCP monitoring program will not attempt to determine the appropriateness of these goals.

Pages 105 through 108 – Section 2.2 - Monitoring, 2.2.3 - Monitoring Variables and Data Collection Methods, Effectiveness monitoring GP-15

The goals set in the PALCO HCP, with respect to effectiveness monitoring can be easily met. The HCP is designed to prevent the following:

1) loss of large woody debris recruitment from timber harvest in riparian zones;
2) increases in water temperature from shade removal; and
3) increases in sediment inputs from surface erosion and landslides that occur due to timer harvest.

The hypotheses identified for LWD is as follows:

1) Over the next two decades, there will be measurable increases in LWD levels due to "extreme" restrictions in riparian zones, prohibition of stream cleaning, and tree blowdown.
2) PL will be able to harvest within the RMZ when basal areas are sufficient to permit harvest.

Many of the preceding statements can, in my opinion, be attained with just standard forest practice rules because it is relative to degraded habitat conditions which have resulted due to minimal forest practice restrictions over the last 50 years. There is no information given in the HCP to determine how attaining the previously stated goals will lead to an increase in coho habitat quality and population levels. In my opinion, these trends are already occurring throughout the Pacific, but population levels continue to decline (Lichatowich and others, 1995). GP-

PALCO identifies many uncertainties associated with the effectiveness of sediment control measures. These statements, however, do not reference any of the scientific literature, and often times, contradict other portions of the plan. For example, PALCO states the following: 15 con.

> The naturally high rate of sediment production makes it difficult to monitor sediment production from management activities (Volume IV, Section 2.2.3, Page 106).

However, PALCO depends on the Washington State watershed analysis methodology for mass wasting and surface erosion. One of the main assumptions in the methods is that sediment production from management v. natural sources can be documented. The methodology used by Pacific Watershed Associates (PWA 1998a&b) also quantifies the difference between management induced and non-management induced landslides. PALCO states this information on page 70 of Volume IV:

> The study (Pacific Watershed Associates study of sediment sources in the lower Eel River) found that 20.1 percent of all landslides occurred in unmanaged areas.

Simple subtraction would tell us that approximately 79.9% of the landslides occurred due to forest management activities. PALCO goes on to state it is not possible to determine a "background" mass wasting rate from the data, which contradicts the conclusion on page 80 that "natural" slides dominate sediment delivery to streams. The impacts to coho habitat from management related landslides and natural landslides could then be identified.

Methods do exist to differentiate between landslides due to management activities v. natural disturbance. This is important, because effectiveness monitoring goals for sediment can then be linked to natural background levels, as opposed to present conditions. PALCO does state the following with regards to this topic:

> Within 5 years of completion of the baseline sediment study, a follow up study will be conducted to determine how many slides have occurred in the interim, their relationship to management activities, and how the rate of management landslides compares to the baseline period (Volume IV, Section 2.2.3., Page 107).

This statement suggests that monitoring efforts will use current conditions as a baseline, and compare them to future conditions. According to PALCO baseline conditions are current conditions, which include a combination of management related and natural landslide activity. Current conditions have resulted in significant adverse effects to fish habitat conditions, thus any comparison to what now exists is irrelevant. Maintenance of current landslide and sediment production rates will continue to result in significant adverse effects to coho habitat.

Pages 108 to 111 – Section 2.2 - Monitoring, 2.2.4 - Cumulative effects analysis GP-16

The PALCO HCP proposes to use trends monitoring to assess whether cumulative effects are "present". PALCO intends to implement trend monitoring in the following manner:

1) Determine whether LWD, canopy/temperature, or sediment conditions are getting worse over time. GP-
2) If conditions are stable, or improve, then assume current practices do not result in a change in stream condition that increase negative impacts to aquatic resources. 16 CON.
3) If conditions become worse, then identify why this is the case, and improve "things".
4) Consult with local, state, and federal agencies.
5) Technical group reviews the results leading to consultation.
6) Identify data collection and analysis efforts the company should undertake "to clarify whether the observed result is due to management activities.
7) If yes, then what can be done to reduce the cumulative effect?
8) What are the appropriate actions taken by the company?
9) Additional monitoring requirements.

PALCO intends to monitor dominant, direct effects, and not use a cumulative effects monitoring tool because "..PL does not believe any cumulative effects assessment methodology is available that can identify the incremental impact of a given amount of management activity."

Trends monitoring of individual variables, such as fine sediment and water temperature, is not a cumulative effects methodology because it does not account for the accumulation of small effects of many forest practices. A cumulative effects analysis includes the necessary assessment tools to integrate different geomorphic inputs in space and time to fish habitat and populations levels (Collins and Pess, 1997b). Assuming that dominant, direct effects monitoring will substitute for such a methodology can result in significant adverse effects from land use practices on fish habitat going unnoticed.

Pages 111 to 113 – Section 2.3 - Adaptive management GP-

An adaptive management plan has four primary goals:

1) clear links between science and management; 17
2) clear and specific goals;
3) implementation management as an experiment, including monitoring designed as a scientific experiment; and
4) institutional learning (Collins and Pess, 199b)

The PACLO HCP does not have a clear link between science and management. Hypotheses, which define goals and management, are assumed to be correct. This limits the ability of "better" science to effect management because if the goals are being met, then management does not change. Even if scientific information could alter management prescriptions, clauses within the HCP prevent this from happening. For example:

> PL, at its discretion, may exceed the maximum limits contained in this agency framework, but, as agreed to by the agencies, cannot be compelled to do so.

PL can decide whether to use scientific information, when it results in prescriptions that are greater than the maximum limit. This reduces the ability for adaptive management to have an effect on what is implemented, and is likely to result in the maintenance of degraded habitat conditions, if the scientific literature determines more than the maximum is needed.

In addition, if the goals are not being met, then the technical evaluation team needs to differentiate why this is happening before a change to the management action occurs. Since there is no direct cause and effect link between resource condition (e.g., a threshold such a number of key LWD pieces) and management practice (e.g., riparian buffer and management options within the RMZ) this cannot happen. PALCO defines the fourth criteria, institutional learning, as "consultation" with local, state, and federal agencies. In my opinion, adaptive management will not occur, due to the maximum limits associated with the HCP. This can result in significant adverse effects to coho habitat, if science identifies areas or restrictions larger than the maximum limits are needed.

GP-17 CON.

REFERENCES

Abbe. T.B., D.R. Montgomery, and C. Petroff. 1997. Design of stable in-channel wood debris structures for bank protection and habitat restoration: Example from the Cowlitz River, WA. In: Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. S.S.Y. Wang, E.J. Langendoen, and F.D. Jr. Shields, (eds.) University, MS. University of Mississippi pp. 809-816

Beechie, T., E. Beamer, L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for restoration. North American Journal of Fisheries Management 14: 797-811.

Beechie, T.J., and T.H. Sibley. 1997. Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams, Transactions of the American Fisheries Society, 126:217-229. AFS

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pp. 191-232 in: (Ed) E.O Salo and T.W Cundy, Streamside Management: Forestry and Fisheries Interactions. University of Washington Institute of Forest Resources Contribution 57. Seattle, WA

Bilby, R.E., B.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into trophic system of small streams: evidence of stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bilby, R.E. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society. 118:368-378.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dollof, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future pp. 143-190 in: (Ed) E.O Salo and T.W Cundy, Streamside Management: Forestry and Fisheries Interactions. University of Washington Institute of Forest Resources Contribution 57. Seattle, WA.

Cederholm, C.J., and N.P. Peterson. 1985. The retention of coho salmon (*Oncorhynchus kisutch*) carcasses in spawning streams. Canadian Journal of Fisheries and Aquatic Sciences 42(8):1347-1355.

Cheng, J.D. 1989. Streamflow changes after clear-cut logging of a pine beetle infested watershed in southern British Columbia, Canada. Water Resources Research 25 (3): 449-456.

Collins, B.D. And G.R. Pess, 1997a, Evaluation of forest practices prescriptions from Washington's watershed analysis program. Journal of the American Water Resources Association. 33 (5): 969-996.

Collins, B.D. And G.R. Pess, 1997b, Critique of Washington's watershed analysis program. Journal of the American Water Resources Association. 33 (5): 997-1010.

Conroy, S.C. 1997. Habitat lost and found, part two. Washington Trout Report 7 (1):1.. pp. 16-22.

FEMAT [Forest Ecosystem Management Assessment Team]. 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. U.S. Government Printing Office.

Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, San Francisco, CA. 818 p.

Haas, A.D., 1996. Coarse sediment storage by large woody debris in small, steep streams of the North Cascades, Washington State. Unpublished thesis, University of Washington. Seattle, WA.

Jones, S.A. and G.E. Grant. 1996. Peak flow responses to clear-cutting and roads on small and large basins, Western Cascades, Oregon. Water Resources Research. 32 (4): 959-974.

Keller, E.A., A. MacDonald, T. Tally, and N.J. Merritt. 1996. Effects of large organic debris on channel morphology and sediment storage in selected tributaries of Redwood Creek. In (Ed) K.M. Nolan, D.C. Marron, and H.M. Kelsey, Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California . United States Geological Survey Professional Paper 1454.

Kelsey, H.M., M. Coghlan, J. Pitlick, and D. Best. 1995. Geomorphic analysis of streamside landslides in the Redwood Creek Basin, Northwestern California. In (Ed) K.M. Nolan, D.C. Marron, and H.M. Kelsey, Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California. United States Geological Survey Professional Paper 1454: J1-J12.

Kennard, P., G. Pess, T. Beechie, B. Bilby, and D. Berg, in press, Riparian-in-a-box: a manager's tool to predict the impacts of riparian management on fish habitat. Proceedings to the Fish-Forest Conference, Trout Unlimited Canada, May 1-4, 1996, Calgary, Canada

Lichatowich. J., L. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in Pacific Northwest watersheds. Fisheries 20 (1):10-18.

McDade, M., F. Swanson, W. McKee, J. Franklin, and J. VanSickle, 1990, Source distances for coarse woody debris entering small streams in western Oregon and Washington, Canadian Journal of Forest Resources. 20: 326-330.

Megahan, W., 1982, Channel sediment storage behind obstructions in forested drainage basins draining the granitic bedrock of the Idaho Batholith, in Sediment Budgets and Routing by Forested Drainage Basins, USDA, Forest Service, PNW Experiment Station, Portland, OR, General Technical Report PNW-141

Montgomery, D.R. and J.M. Buffington, 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin. 109 (5): 596-611.

Montgomery, D.R., T.B. Abbe, J.M. Buffington, N.P. Peterson, K.M. Schmidt, and J.D. Stock. 1996. Distribution of bedrock and alluvial channels in forested mountain drainage basins. Nature. 381:587-589.

Montgomery, D.R., 1993. Road Surface Drainage, Channel Extension, and Slope Stability, in Geomorphological Watershed Analysis Project, final Report for the period from 10/1/91 to 6/3/93. Report to Timber/Fish/Wildlife. TFW-SH01-93-001

Montgomery, D.R., J.M. Buffington, R.D. Smith, K.M. Schmidt, and G. Pess, 1995, Pool Spacing in Forest Channels, Water Resources Research, Vol. 31, No. 4, pp. 1097-1105

Montgomery, D.R., E.M. Beamer, G. R. Pess, T.P. Quinn. In press. Channel type and salmonid spawning distribution and abundance. Canadian Journal of Fisheries and Aquatic Sciences.

National Marine Fisheries Service (NMFS). 1996. Coastal salmon conservation: working guidance for comprehensive salmon restoration initiatives on the Pacific coast. September 15, 1996. NOAA, U.S. Department of Commerce.

Pess, G.R., M.E. McHugh, D. Fagan, P. Stevenson, and J. Drotts. 1997. Stillaguamish Salmonid Barrier Evaluation and Elimination Project, Phase III, final report. The Tulalip Tribes, Marysville, WA.

Reeves, G.H., J.D. Hall, T.D. Roeloefs, T.J. Hickman, and C.O. Baker. 1991. Rehabilitating and modifying stream habitats, in: (Ed) W.R. Meehan, Influences of forestry and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 519-558.

Scarlett, W.J. and C.J. Cederholm. 1984. Juvenile coho salmon fall-winter utilization of two small tributaries of the Clearwater River, Jefferson County, Washington. Pages 227-242 in J.M. Walton and D.B. Houston, editors. Proceedings of the Olympic wild fish conference. Peninsula College, Fisheries Technology Program, Port Angeles, Washington.

U.S Fish & Wildlife Service and California Department of Forestry and Fire Protection. 1998. Draft Environmental Impact Statement/Environmental Impact Report for the Headwaters Forest Acquisition and the PALCO Sustained Yield Plan and Habitat Conservation Plan, Volume I & II, Chapters 1 through 3.11 and appendices. Sacramento, CA.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 40:452-461.

Van Sickle, J. and S.V. Gregory, 1990. Modeling inputs of large woody debris from falling trees. Canadian Journal of Forestry Research 20: 1593-1601.

Wemple, B. 1994. Potential Hydrologic Effects of Logging Access Roads in Forested Landscapes of the Western Cascades, Oregon. M.S. Thesis, Department of Geosciences, Oregon State University, Corvallis, OR.

WFPB, Washington Forest Practices Board, 1995, Stand Methodology for Conducting Watershed Analysis under Chapter 222-22 WAC, version 3.0, November 1995, Olympia, WA